

WHAT IS CLAIMED IS:

1. A variable-valve-actuation (VVA) apparatus for an internal combustion engine with a valve, comprising:

5 a control shaft arranged rotatable in accordance with operating conditions of the engine;

an alteration mechanism which changes at least an operating angle of the valve in accordance with rotation of the control shaft; and

a drive mechanism which rotates the control shaft, the drive mechanism comprising an electric motor and a reduction mechanism, the reduction mechanism
10 having a reduction ratio set to be larger when the valve is under control of small operating angle than when the valve is under control of large operating angle.

2. The VVA apparatus as claimed in claim 1, wherein the reduction mechanism comprises:

15 an output shaft linked to the motor and having at an outer periphery an engagement;

a moving member meshed with the engagement of the output shaft, the moving member moving in an axial direction of the output shaft in accordance with rotation of the output shaft;

20 a link member having a first end swingably linked to the moving member; and

a linkage swingably linked to a second end of the link member, the linkage rotating the control shaft by torque transmitted from the link member in accordance with axial movement of the moving member,

25 wherein when the valve is under control of small operating angle, an angle formed between the link member and the output shaft is increased.

3. The VVA apparatus as claimed in claim 1, wherein the alteration mechanism is rotated in synchronism with a crankshaft of the engine, the alteration mechanism comprising a driving shaft having at an outer periphery a crank cam, a VO cam

swingably supported on a support shaft and having a cam face which comes in contact with a top face of a valve lifter to carry out opening and closing operation of the valve, and a rocker arm having a first arm mechanically linked to the crank cam and a second arm linked to the VO cam through a link rod,

- 5 wherein a rocking fulcrum of the rocker arm is changed in accordance with the engine operating conditions to change a position of contact of the VO cam with respect to the top face of the valve lifter, thus varying valve lift.

4. The VVA apparatus as claimed in claim 2, wherein the output shaft of the
10 reduction mechanism comprises a threaded shaft having an external thread formed on an outer peripheral surface, and the moving member comprises a threaded nut having an internal thread formed on an inner peripheral surface, wherein the external thread is meshed with the internal thread.

- 15 5. The VVA apparatus as claimed in claim 2, wherein the output shaft of the reduction mechanism comprises a threaded shaft having a spiral ball groove formed in an outer peripheral surface, and the moving member comprises a threaded nut having a guide ball groove formed in an inner peripheral surface, wherein the ball groove cooperates with the guide ball groove to hold a plurality of balls in a free-roll manner.

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6. The VVA apparatus as claimed in claim 2, wherein the linkage of the reduction mechanism is fixed to the control shaft, wherein a pivotal point of the linkage with the link member is offset with respect to an axis of the control shaft.

- 25 7. The VVA apparatus as claimed in claim 2, wherein when the valve is under control of maximum operating angle, the angle formed between the link member and the output shaft is minimum.

8. The VVA apparatus as claimed in claim 2, wherein when the valve is under

control of minimum operating angle, the angle formed between the link member and the output shaft is maximum.

9. The VVA apparatus as claimed in claim 2, further comprising a restriction
5 mechanism which restricts maximum axial movement of the moving member.

10. The VVA apparatus as claimed in claim 2, wherein the moving member is moved axially without being rotated.

10 11. The VVA apparatus as claimed in claim 1, wherein the reduction mechanism comprises:

an output shaft linked to the motor and having at an outer periphery an engagement;

15 a moving member meshed with the engagement of the output shaft, the moving member moving in an axial direction of the output shaft in accordance with rotation of the output shaft, the moving member comprising a pin; and

a link lever having a first end fixed to the control shaft and a second end formed with a slit, the slit being engaged with the pin,

20 wherein the control shaft is rotated through the link lever in accordance with axial movement of the moving member, and

wherein when the valve is under control of small operating angle, an angle formed between the link lever and the output shaft is decreased.

12. A variable-valve-actuation (VVA) apparatus for an internal combustion engine
25 with a valve, comprising:

a control shaft arranged rotatable in accordance with operating conditions of the engine;

an alteration mechanism which changes at least an operating angle of the valve in accordance with rotation of the control shaft; and

a drive mechanism which rotates the control shaft, the drive mechanism comprising an electric motor and a reduction mechanism, the reduction mechanism having a reduction ratio set to be larger when the valve is under control of small operating angle than when the valve is under control of large operating angle,

5 the reduction mechanism comprising:

an output shaft linked to the motor and having at an outer periphery an engagement;

a moving member meshed with the engagement of the output shaft, the moving member moving in an axial direction of the output shaft in accordance with rotation of the
10 output shaft;

a link member having a first end swingably linked to the moving member; and

a linkage swingably linked to a second end of the link member, the linkage rotating the control shaft by torque transmitted from the link member in accordance with axial movement of the moving member,

15 wherein when the valve is under control of small operating angle, an angle formed between the link member and the output shaft is increased.

13. A variable-valve-actuation (VVA) apparatus for an internal combustion engine with a valve, comprising:

20 a control shaft arranged rotatable in accordance with operating conditions of the engine;

an alteration mechanism which changes at least an operating angle of the valve in accordance with rotation of the control shaft; and

a drive mechanism which rotates the control shaft, the drive mechanism
25 comprising an electric motor and a reduction mechanism, the reduction mechanism having a reduction ratio set to be larger when the valve is under control of small operating angle than when the valve is under control of large operating angle,

the reduction mechanism comprising:

an output shaft linked to the motor and having at an outer periphery an

engagement;

a moving member meshed with the engagement of the output shaft, the moving member moving in an axial direction of the output shaft in accordance with rotation of the output shaft, the moving member comprising a pin; and

5 a link lever having a first end fixed to the control shaft and a second end formed with a slit, the slit being engaged with the pin,

wherein the control shaft is rotated through the link lever in accordance with axial movement of the moving member, and

10 wherein when the valve is under control of small operating angle, an angle formed between the link lever and the output shaft is decreased.

14. A variable-valve-actuation (VVA) apparatus for an internal combustion engine with a valve, comprising:

15 a control shaft arranged rotatable in accordance with operating conditions of the engine;

means for changing at least an operating angle of the valve in accordance with rotation of the control shaft; and

20 means for rotating the control shaft, the rotating means comprising means for proving torque and means for reducing the torque, the reducing means having a reduction ratio set to be larger when the valve is under control of small operating angle than when the valve is under control of large operating angle.